Cefas

Individual CIE Report

SARC 51: silver hake, red hake, offshore hake and the squid *Loligo pealeii*.

Prepared for the Center for Independent Experts

By

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Executive Summary

- This is the individual CIE Reviewer report of the SARC 51 review for silver, red and offshore hakes and the squid *Loligo pealeii* and solely represents the views of the author.
- This reviewer agrees with all of the findings reported in the SARC 51 review for silver hake, red hake and offshore hake but has reservations about some of the findings reported for *Loligo* squid in the Panel Summary Report (*Summary Report*). Findings that are fully reported in the *Summary Report* are not necessarily repeated in this individual report although much is repeated where pertinent. This report also presents clarifications of elements in the summary report plus some additional views of the individual reviewer which may not have been fully discussed by the Panel or at the SARC 51 meeting.
- The assessment teams addressed all of their review Terms of Reference (ToR) as far as it was possible to do so.
- The analytical assessment outputs for **silver hake** based on the ASAP model had some limitations and were not suitable for providing management advice. New BRPs were proposed but increasing estimates of total mortality (Z) indicates that these may not be appropriate.
- The analytical assessment outputs for **red hake** were not robust and were not suitable for providing management advice. New BRPs were proposed and the status of the stocks evaluated, where in comparison against the new BRPs neither stock was overfished or was experiencing overfishing.
- The assessment for **red hake** was built upon considerably enhanced data that included longer times series of landings and fishery indices, but also new attempts at clarifying discards, estimating landings by species (addressing misidentification issues) and consumption by the major predatory fish. Overall, this represents a major effort in improving the input data for this species and will provide a sound platform on which to develop future assessments.
- Due to the inadequacies of the available data, no adequate model could be developed from which to derive management advice for the stock of **offshore hake**. There are possibilities of improving the data over time but this stock will probably remain difficult to find an adequate assessment method for.
- The assessment for ***Loligo*** was developed to meet the needs of the management framework and the given ToR but are, in the view of the reviewer, not appropriate to the biology of this short-lived, two-cohort per year species and is not suitable for providing management advice.
- Recommendations are made for more effective and precautionary assessment and management of ***Loligo***, to protect the stock better and enable greater exploitation.
- This reviewer believes that there are a number of data issues that need to be addressed in order to improve the quality and reliability of future assessment of each species. These are, for the three hakes, the adequacy of the surveys (area of coverage, efficiency of gear) and for ***Loligo*** the use of detailed, short time-step commercial catch and effort data and efficiency of survey gear.
- Recommendations aimed at improving the current approach to stock assessments for the four species through additional research are made in this report. Readers should refer to the main text for discussion.

Introduction

This SARC Review Panel met as intended and focused on reviewing and providing support to the development of the best approaches to assessment for management purposes, of the four species during the review process.

All presenters provided clear and informative material and were constructive and helpful in providing clarifications. The tone of the meeting was both very positive and constructive throughout.

The *Summary Report* of the SARC 51 Review Panel was well drafted and this report draws heavily on the wording in the *Summary Report*. All views expressed in this report are, however, those of this reviewer.

Description of review activities

This review was undertaken by Dr Geoff Tingley in Woods Hole, Massachusetts over the period 29th-November to 3rd December 2010 as part of the SARC 51 Review Panel for silver hake, red hake, offshore hake and the squid *Loligo pealeii*. Relevant documents (see Bibliography, Appendix 1) were made available prior to the meeting via a link to an ftp server. The documentation so provided was reviewed prior to the meeting.

The Panel was comprised of individuals with a wide variety of skills and experience appropriate to this diverse SARC, including modeling skills, specific biological expertise and expertise in data. The Panel was courteously and very effectively led by the chair and worked well as a team.

During the meeting, all presentations, additional material and the results of requests made by the Panel were uploaded onto the ftp server for common access by all participants. This process worked well. Uploading of the presentation material prior to each presentation was also a great assistance as this enabled Panel members to review figures in the presentation while continuing to follow the live action.

The background information and assessment for each species was presented by the assessment leaders, who were ably supported by members of their various teams. A number of other participants also provided clarifications and useful inputs. The quality of all presentations was high as was the participation by others present at the meetings. All presentations were made by NEFSC staff as follows: L. Alade - silver hake, K. Sosebee - red hake, M. Traver – offshore hake, L. Hendrickson – longfin squid. J. Link and P. Rago, also of the NEFSC, contributed to these presentations.

Jim Weinberg (SAW Chair) provided excellent co-ordination of the meeting, procedural guidance and in report preparation. He was ably supported by his staff and also by Paul Rago.

Documents for the silver hake, red hake and offshore hake assessments were prepared by the Hake Working Group. The longfin squid assessment documents were prepared by the Invertebrate Working Group.

Rapporteurs recorded the discussion to assist the Panel in its deliberations: M. Palmer for silver hake, T. Wood for red hake, J. Nieland for offshore hake and T. Chute for longfin squid.

A few participants from, or representing, the industry were present during the meeting and contributed actively and constructively to the meeting, providing some key clarifications for the Panel.

Background information relevant to this review is presented in a series of appendices, including a Bibliography (A1); the CIE Statement of Work (A2) (which includes (i) the Format and Contents of the CIE Peer Review Report, (ii) Assessment Terms of Reference for SAW/SARC51, (iii) Tentative Agenda), and (iv) Contents of the SARC Summary Report.

Comments are provided against the specific Terms of Reference (ToR) given in Appendix 2.

Comments on the SARC Process.

Some of the assessment working papers came in relatively late but the Panel understood the reasons why and appreciated the efforts of the working group to provide the best available information for the review. Panel members were able to complete a thorough review of all the assessment working papers.

The Panel was asked to assist in drafting the summary assessment reports. Panel members felt that they were qualified to review the science in the assessments but less so to draft the management advice which requires local knowledge that Panel members may or may not have had.

Panel members were concerned that the remit for *Loligo* squid was based on the standard "fish" approach to management with reference points, annual ABC, OFL, etc. for a species which lives less than one year and where there are two cohorts with some degree of separation. For such a species - adequate spawner escapement from each seasonal fishery is required to ensure sufficient recruitment in subsequent seasons. In–season assessment and management is also necessary to extract optimum yield. Averaging across single or multiple years for biomass is not appropriate with such biology.

The Panel noted that changing from the RV *Albatross IV* to the RV *Bigelow* introduced additional uncertainties in the assessments but the change will be beneficial in the medium term for all four species reviewed as the fishing gear used on the Bigelow seems more appropriate for both hake and *Loligo* squid. The Panel concurs with working group members that adjusting past population estimates for hakes will require considerable care as the conversion factor(s) appear to vary by length.

The Panel considered that the introduction into the assessment, of consumption estimates by predators, is a considerable improvement towards a better understanding of the factors affecting change in abundance of both predators and prey. The Panel encourages the continued improvement in estimating consumption and its use in multispecies modeling, as soon as is considered appropriate for the provision of management advice.

Summary of findings

The Panel reached consensus on all Terms of Reference (ToR) for each stock and the reviewer fully agrees with all of the findings reported in the *Summary Report* relating to hake but holds slightly different views from other Panel members about some of the findings for *Loligo*. This report focuses on clarifications of elements in the summary report plus some additional views of the individual reviewer that may not have been fully discussed by the meeting or the Panel. Findings that are fully reported in the *Summary Report* are not necessarily repeated in this individual report.

The principal finding is that all terms of reference that could be addressed, were met.

The assessment teams should be commended for their thorough and professional approach to preparing the various data and in developing and applying the models to provide the best advice to managers on these four species. The openness of the discussions and the breadth and depth of the information presented during the review greatly aided the review process. A summary of findings and recommendations from this reviewer for each species are presented below, addressing each of the Terms of Reference (ToR) as set out in Appendix 2. The rapporteurs are to be congratulated for their excellent contribution.

Where no recommendations are made against a specific ToR, this is because the reviewer believes that the *Summary Report* of the Panel has made the appropriate recommendations in full or that no further comments are required.

A: silver hake (northern and southern) (*Merluccius bilinearis*).

Summary for silver hake

- This assessment follows on from one conducted in 2006, but with considerably increased data available, including age composition and predator consumption data.
- The data available on which to base a decision of whether the silver hake should be considered as one or two (northern & southern) stocks was not equivocal.
- One of the model approaches used, ASAP, was useful in exploring the fishery and survey data but was compromised by age-related and temporal trends in the catchability of the low headline-height research survey trawl, which is not of an optimal design for surveying a species such as hake which migrates vertically over a very wide depth range.
- Future assessments should include a rigorous evaluation of factors such as depth, area and fish size on catchability which would require data on size/age related vertical distribution patterns according to depth, area and time of year.

Comments on Individual Terms of Reference: silver hake (northern & southern)

1. *Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.*

The *Summary Report* fully reflects the position of this fishery. In brief, there are detailed landings data of variable quality for different time periods, with some concern over the very large reported removals early in the time series. These are supported by some, but not sufficient, biological data sampled from particularly, the research surveys.

Weight and length at age data were obtained solely from the fishery surveys. The commercial catches were sampled by the observer program for length frequency.

Landings of hake prior to 1991 were not separated by species. Since 1991 landings have been by species, but with an unknown level of accuracy and indications that this is probably fairly patchy. Length and depth-based methods for distinguishing between silver and offshore hake have been developed and applied, yielding similar results.

Discards are believed to typically be 20 to 30% of the catch by biomass. The same approach to estimating discards by species was followed as for landings in a consistent manner. The absolute level of discarding is subject to some uncertainty, as observer sampling effort has been low and patchy.

Sampling of the commercial catch for biological data has also been inconsistent and no age data from the commercial fishery were available to support the assessment. All age information came from data collected from the research surveys and may be subject to the sampling bias due to the significant differences between the research and commercial gear types used. For an age-based assessment, this is a weakness that should be addressed by obtaining age data directly from the fishery.

2. *Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.*

The Panel concluded that this ToR was mostly met. The design, implementation and analysis of the NEFSC survey data were appropriate for silver hake and the precision of the surveys was calculated, however, potential biases in the surveys were not sufficiently addressed by the Hake Working Group.

The principal concern was that the trawl gear used on the historical NEFSC trawl surveys is likely to be sub-optimal for a survey of hake stocks due to the low headline height (1 – 2 m). Silver hake exhibit strong diel vertical migration patterns and the proportion occurring close enough to the seabed to be caught by the research trawl during the day is unknown. The small demersal trawl on RV *Albatross* is likely to suffer from large variations in capture efficiency for all species of hake and this may be related to depth, fish size, water temperature, light intensity and the location of prey species in the water column. Shifts in the spatial distribution of the stock between years could also induce changes in overall catchability across years and ages. Commercial fisheries for hake worldwide tend to use high vertical opening otter trawls, mid-water trawls or gillnets that would be expected to improve capture efficiency. Comments made by fishing industry participants at SARC-51 indicated that commercial trawls used for silver hake have substantially higher headline heights than the research trawls used. It was therefore recommended by the Panel that a rigorous evaluation of the catchability of hake taken by the research trawl be conducted, possibly along the lines of the analysis of the components of catchability for *Loligo pealeii* in the current review. Of particular importance is the proportion of hake in the water column that are close enough to the seabed to encounter the net, according to depth, area and fish size, and how this may interact with shifts in population distribution to cause trends in survey catchability. This would require data on size/age related vertical distribution patterns, for example, using acoustics or mid-water nets. This should build on GAM modeling conducted in the 2006 assessment of silver hake to investigate factors affecting apparent distribution of silver hake of different sizes in the NEFSC surveys. The Panel recognized that the factors or their coefficients may change over time.

The spring survey may be more susceptible to catchability trends that the fall survey due to the concentration of hake along the shelf edge in deep water at this time. During the spring, relatively small changes in the distribution of silver hake could have large effects on the availability of silver hake to the survey. This may affect the southern region more than the north, due to the greater overall depths across the northern survey area and the more uniform distribution in this area. Ideally, more information is needed on the offshore extent of the population relative to the survey. If the surveys were accurately tracking population biomass, changes in fishery catches should be followed by changes in survey biomass estimates. However, the AIM analysis indicated no significant effect of relative F (catch/biomass) on the replacement ratio, and several temporal "regimes" were evident in the relationship between the survey index and relative F. This suggests that factors other than abundance are affecting the survey trends, and/or that fishing mortality is too low for any changes to have a discernible effect on survey trends.

The Hake Working Group provided no information on sampling rates for age composition in the surveys, or how the data were applied (e.g. the spatial scale at which ALKs are applied). An additional analysis of internal consistency of the survey age compositions (plots of $N_{a+1,y+1}$ vs $N_{a,y}$) was requested by the Panel. Some relatively strong year classes could be tracked over a few years, but the internal consistency was otherwise relatively poor. This could be a consequence of applying ALKs in a way that does not account adequately for spatial patterns in age-at-length, errors in ageing, or relatively low recruitment variability, resulting in a low signal to noise ratio in the survey catches at age. Using ALKs from the survey to estimate the age composition the commercial fishery may also contribute to this problem.

The Panel agrees with the Hake Working Group that the calculation of survey indices based on arithmetic means of station catch rates within survey strata, is more appropriate for this stock than the use of the delta method. Since the change in vessel from RV *Albatross* to RV *Bigelow* in 2009, a larger otter trawl with a greater vertical opening has been used. There are many other differences in vessel operation, gear and towing procedures, including towing speed. Differences in catchability at length between the two research vessels were estimated from, 636 paired tows in 2008, indicating much higher overall catch rates of silver hake for the new vessel/gear combination. Catch rates for 10-20cm fish were around 5 – 10 times larger in the new net, but the catch rates for 30cm+ hake were only 1-4 times larger.

For this assessment, data from the new vessel were converted to "*Albatross* equivalents". For the short- to medium-term, it would be better to rework the *Albatross* data series into "*Bigelow* equivalents" on a one-off basis rather than continue to recalculate new (Bigelow) data into "*Albatross* equivalents" several times per year. This should both reduce the effort required for each future survey analysis and also reduce the possibility of recalculation errors. Eventually the data from the RV *Bigelow* using the new trawl should be treated as a separate survey series for use in assessments, recognizing that catchability at length is different in the two gears.

Three errors and anomalies in the SAW report, relating to surveys, were picked up by the Panel and are fully described in the *Summary Report*.

3. *Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.*

The Panel supported the conclusions of the Hake Working Group that evidence for the existence of separate northern and southern stocks of silver hake is equivocal.

Additional information in the form of maps of egg distribution from the MARMAP surveys was provided to the Review Panel. These did not indicate discontinuity in spawning distributions across the boundary between the northern and southern regions used for the existing stock definition.

4. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results*.

The WG fully addressed this Term of Reference.

The assessment models are appropriate to the data available and appear to have been applied appropriately. The Panel concluded that the model proposed by the Hake Working Group is not yet suitable as a basis for developing management advice for a number of reasons, outlined below.

Substantial and valuable exploratory work had been carried out on the age-based data for the survey, fishery and for predator consumption, using the statistical age-structured model ASAP (Age Structured Assessment Program). M was modeled as a predation mortality component (M2, estimated separately by age and year from predator consumption) with a fixed value of M1=0.15 used across all ages and years representing other sources of mortality. The exploratory runs evaluated the effects of choices regarding selectivity at age in the surveys, fishery fleets and the predator "fleet", including the effects of choices of year blocks for fitting selectivity. The sensitivity to excluding the predator data and using a larger constant M1 across ages was examined.

Key observations were:

a) a very steep decrease in abundance with age in the survey (and directed fishery age compositions) which became progressively steeper over time, suggestive of high and increasing total mortality;
b) survey indices of combined-stock abundance that suggest a general increase in total numbers over time up to about year 2000, followed by a decline (additional analyses showed this to be mainly driven by younger hake, whilst numbers of older 3+ hake have declined in the fall surveys).

The exploratory ASAP runs provided divergent trends in spawning stock biomass (SSB) and fishing mortality depending on how the model was allowed to fit to the age composition data or the trends in abundance indices. The trends in fishing mortality and SSB from the exploratory ASAP runs tended to cluster into two scenarios: (i) declining fishing mortality and generally increasing SSB up to the early 2000s followed by a decline, and (ii) increasing fishing mortality, declining SSB, and a poor fit to the survey abundance indices suggesting a trend of increasing catchability over time in the surveys. The runs yielding scenario (i) were those in which selectivity in the surveys and directed fishery fleet (landings) was allowed the flexibility to be domed rather than fixed to be flat-topped. The runs yielding scenario (ii) were those in which selectivity was fixed to be flat topped.

In scenario (i), the dome in the fishery selectivity was allowed to vary in the different time blocks. This gives additional flexibility to fit the temporal trends in the survey abundance indices by adjusting fishery selectivity over time. A strong survey selectivity dome means that the fitted survey age compositions become more dominated by younger hake, as is observed. In combination, these lead to an apparently good fit to the selectivity-corrected age-aggregated abundance indices from the surveys, whilst also fitting the fishery data well. In scenario (ii), the flat-topped selectivity forces the model to interpret the steep decline in abundance with age in the survey and catches as high and increasing mortality rates. However the trade-off is that the model estimates of age-aggregated biomass follow different trends to the observed values, showing a declining trend that suggests an increase in survey catchability over time.

Model configurations allowing domed selectivity generated a large "cryptic" (unobserved) population of older hake that have a very low probability of being caught by the fishery or survey. As there is no evidence for a large cryptic biomass, the Hake Working Group preferred to force a flat-topped selectivity for the surveys and directed fishery. This model configuration was the basis for the Hake Working Group recommending ASAP run 6 in the assessment report, as the best interpretation of the data, and this run was used for developing management advice in the assessment report.

Additional runs were presented to the Panel to further explore the sensitivity of the ASAP:

Run 1-1: No consumption estimates included; M1 fixed at 0.5, 0.6 or 0.7.

Run 3-1: Flat top selectivity, with time invariant M2 vector determined as the time series average M2 at age from the run 6 including the predator fleet.

Run 5-1a: Fit using fall survey only, with domed selectivity allowed.

Run 5-1b: Fit using spring survey only, with domed selectivity allowed.

In Run 1-1, the higher values of M1 reduced the cryptic biomass, although this implies mortality that cannot at present be attributed to any source. The Panel notes, however, that there are predators not included in the consumption estimates including marine mammals, seabirds and invertebrates (e.g. squid) which will contribute to total mortality.

Run 3-1 provided results very close to run 6 (the proposed base model), except that there is no longer a period of reduced recruitment early in the time series caused by the lower estimates of consumption at the beginning of the stomach sampling program.

Run 5-1a provided results generally similar to run 6 (base model) despite allowing a dome to be fitted to the fall survey. In this case, the selectivity dome for the survey was not extreme and the directed fishery selectivity was more-or-less flat-topped. However, retrospective runs showed that the model fit flipped to scenario (i) with declining F and increasing SSB as the terminal year was peeled back, indicating an unstable assessment. This was clear indication that the data are inadequate to allow selectivity to be freely estimated over all ages in the fishery and survey, including in different fishery time blocks.

The Panel was unable to select any single ASAP run as a suitable basis for providing management advice. Although it appears advisable to fix the directed fishery selectivity on older ages, rather than allowing it to be freely estimated, this leads to strongly auto-correlated trends in survey residuals. This suggested that there are factors other than abundance affecting survey trends in a non-random way.

Until the existence of year, area or size/age effects on the catchability in the NEFSC surveys are demonstrated through appropriate data and analysis, the existence of a "cryptic" biomass is proven, or significant consumption of older hake by predators not yet sampled is demonstrated, it is not possible to make an objective decision on a the most appropriate ASAP model configuration. The current state of the stock is therefore considered unknown, as two very different interpretations of the data are possible.

An update of the AIM (An Index Method) approach was also carried out to evaluate if changes in relative fishing mortality (annual fishery catch divided by the survey biomass index) lead to subsequent coherent changes in survey biomass index, and to estimate the relative F at which biomass replacement occurs. No significant relationship was detectable between replacement ratios and relative F, and several temporal stanzas were evident in the relationship between survey index and relative F. The results suggest that factors other than fishing are affecting the survey trends, or that F is too low for the fishery to have a detectable effect. This would be consistent with evidence from ASAP that catchability in the survey could be changing over time.

5. *Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.*

The Hake Working Group met this ToR. The estimates of minimum consumption for the suite of fish predators examined were appropriate for examining potential magnitude and changes in M over time and for evaluating the age profile of M. The M2 estimates from the ASAP runs showed no trend over time, despite there being trends in hake biomass. However, the predator consumption estimates must be considered biased in absolute terms, and possibly temporally and spatially as well, depending on the trends in consumption by predators not included in the estimates. Nonetheless, the consumption estimates are an important development for progressing ecosystem-based fisheries management. Further development of this should be conducted to refine what has been done and to include other predators in the estimation.

6. *State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for BMSY, BTHRESHOLD, and FMSY; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.*

The Hake Working Group correctly stated the existing stock status definitions and met the ToR by proposing new BRPs, estimates or proxies for BMSY, BTHRESHOLD, and FMSY based on the ASAP model results. In the absence of an agreed ASAP model run, the BRPs for the northern and southern silver hake stocks were updated at SARC-51 as follows:

Silver hake is overfished when the three-year moving average of the fall survey weight per tow (i.e. the biomass threshold) is less than one half the BMSY proxy, where the BMSY proxy is defined as the average observed from 1973-1982. The current estimate of biomass threshold for the northern stock is 3.21kg/tow and 0.83kg/tow for the southern stock.

Overfishing occurs when the ratio between the catch and the fall survey biomass threshold exceeds 2.78kt/kg for the northern stock area and 52.30kt/kg for the north and southern stock areas.

There are indications from the ASAP assessment and from declining catch rates of age 3+ in the fall survey (when hake are more widely distributed over the shelf), that total mortality is increasing. This suggests that the reference points above may no longer be appropriate.

7. *Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Silver hake TOR 6).*

This ToR was fully addressed. The Hake Working Group evaluated stock status based on their preferred ASAP run. However, as this ASAP run was not accepted as a basis for providing management advice, the status of the stock was evaluated at SARC 51 based on the revised BRPs from ToR 6 (above).

Under the proposed BRPs using arithmetic means to calculate survey indices of abundance, the northern stock of silver hake is **not overfished** and **overfishing is not occurring**. The three year arithmetic mean biomass, based on the NEFSC fall bottom trawl survey data for 2007-2009 (6.20kg/tow), was above the proposed management threshold (3.21kg/tow) and below the target (6.42kg/tow). The exploitation index (total catch divided by biomass index, for 2007 – 2009 (1.25kt/kg) was below the threshold (2.78kt/kg).

Similarly under the proposed BRPs, the southern stock of silver hake is **not overfished** and **overfishing is not occurring**. The three year arithmetic mean biomass, also based on the NESFC fall bottom trawl survey data for 2007-2009 (1.11kg/tow), was above the management threshold (0.83kg/tow) and below the target (1.65kg/tow). The exploitation index, for 2007-2009 (7.11kt/kg) was below the threshold (52.30kt/kg).

8. *Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).*

    a. *Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).*
    b. *Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.*
    c. *Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.*

The ASAP model was not accepted as a basis for providing management advice and so multi-year projections were not possible.

9. *Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.*

The Hake Working Group addressed this ToR by reviewing previous SARC and WG recommendations and their continued validity and also provided nine new recommendations, one of which was addressed at SARC (use of constant M2 at age based on the variable estimates in Run 6). The new recommendations will improve knowledge of silver hake but were not prioritized.

One of the recommendations, that to estimate discard mortality (i.e. proportion of discarded hake that die), is not considered necessary, as the experience of commercial trawling, given longer towing time than research trawling, is that the vast majority of hake brought on board are either dead or would not survive return to the water.

Silver hake recommendations

The Panel made a number of additional research recommendations:

1) If an age-based assessment is considered, age data should come directly from the fishery rather than from the survey, or that at least comparisons between fishery and survey-based age data should be statistically compared to demonstrate that they are sufficiently similar not to introduce unnecessary uncertainty into the assessment.
2) Collection of data on size/age related vertical distribution patterns according to depth, area and time of year, for example using acoustics, to allow a more rigorous evaluation of factors such as depth, area and fish size on survey catchability.
3) Given the limitations of trawl surveys for assessing silver hake, consideration should be given to developing other survey approaches such as acoustics or egg production surveys. Applications of the daily egg production method are being developed for European hake (Murua *et al,* 2010).

4) Consideration should be given to use of linked VMS and landings/sampling data to investigate spatio-temporal effort and CPUE and standardized CPUE indices for vessels that fish for silver hake.
5) Further work should be conducted to refine and expand the consumption estimates to include more predator species, including those that may feed on older hake.

Additional research recommendations identified by this reviewer, in priority order, are:

CIE Reviewer silver hake recommendations *(for next benchmark review).*

Silver hake recommendation 1.

Biological data (length, weight, sex, maturity and especially age (otoliths)) should be collected directly from the commercial catches by observers/port sampling. The current reliance on using the research surveys to provide the vast majority of biological data (and all age data) leaves the assessment open to unquantifiable uncertainty if the surveys do not effectively sample the hake populations (as is suspected). This was also a recommendation from previous SARC reviews and was in part a Panel recommendation (1 above).

Silver hake recommendation 2.

The uncertainty as to whether the silver hake occurs as a single stock or two stocks is a fundamental issue that impacts the assessment and management of this species. This should initially be addressed by comparison of samples from the two areas by one or preferably more methods, including genetic comparison, preferably supported by morphometric analyses from the whole range of this species. Ideally this should form part of wider assessment of the sympatric hakes in this region.

Silver hake recommendation 3.

Silver and offshore hake (*Merluccius albidus*) are sympatric species and co-exist over a considerable range of the continental slope. The confusion between these species in the catches (landings and discards) is currently addressed in the assessment by splitting the catch by depth which introduces uncertainty into the assessment. This issue should be directly addressed by collecting samples through the observer program (or port sampling) to provide data that can be used to differentiate the catches based on direct species identification from within the catches based on morphometric and/or genetic analyses. This could be part of a larger program to address the SARC Panel recommendation #4 above.

Silver hake recommendation 4.

Following the changeover to the new research vessel (*Bigelow*), the most recent survey indices have been recalculated to be equivalent to those derived using the old research vessel (*Albatross*) i.e. as "*Albatross* equivalents". While this may have be appropriate following the first surveys by the new vessel, given that all future data will be collected using the new vessel, it would be more appropriate, for the short- to medium-term, to recalculate the historic data and express them in '*Bigelow'* equivalents for future use. This should both reduce the effort required for each future survey analysis and also reduce the possibility of recalculation errors. Eventually the data from the RV *Bigelow* using the new trawl should be treated as a separate survey series for use in assessments, recognizing that catchability at length is different in the two gears.

Silver hake recommendation 5.

To address the uncertainties about migration in silver hake, the development of conventional, data storage tag or hook-based tagging studies to provide information about migration, should be considered. This should probably be considered as part of a larger program to address distribution and migration issues for all of the sympatric hake species.

B: red hake (northern and southern)

Summary for red hake

The previous assessment of red hake (*Urophycis chuss*) was in 1990 (SAW 11). It was an index-based assessment and there were no reference points. The current assessment makes use of fishery landings, discard estimates and length frequency data, together with survey length frequency, age composition data and some predator consumption estimates for the fifteen principal predatory fish. Three assessment methods were used: AIM (An Index Method), SCALE (Statistical CAtch at LEngth model) and SS3 (Stock Synthesis 3). While not statistically significant, the AIM analysis did provide a basis to inform decisions about reference points. The SCALE method failed to produce much insight as it experienced problems in fitting the length composition data, a problem that increased in magnitude in the more recent years and also demonstrated bad retrospective patterns. SS3 also experienced difficulties in fitting the length composition data. SS3 was able to handle the consumption (predation) data but was unable to fit the length composition of the consumption data. That two of the modeling approaches tried, experienced difficulties in fitting the length composition data, suggests that there may be some data issues to be addressed in the length composition data.

The application of these three modeling approaches was built upon considerably enhanced data that included longer times-series of landings and fishery indices but also new attempts at clarifying discards, estimating landings by species (addressing mis-identification) and consumption by fifteen main fish predators. This represents a major effort in improving the input data for these (and other species).

Overall the assessment moved the understanding of the population of red hake and its fisheries forward considerably.

Comments on Individual Terms of Reference: red hake (northern & southern)

1. *Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.*

The Assessment Team met this ToR in terms of reconstructing historical landings, discards and associated length/age compositions, as far as was possible within the constraints of the available data. Fishery effort and LPUE data were not presented due to concerns over the effect of management regulations. It is considered that the presentation of regional time-series of effort data for the main fleets exploiting red hake would have been valuable for determining regional impacts on the stock.

The Hake Working Group discussed in detail whether there was sufficient fishery data to support an assessment or not, without coming to a clear conclusion. The fishery data appear to adequately reflected the overall history of the fishery but is subject to the following key uncertainties:

(i) The accuracy of the historical nominal landings, particularly for the Distant Water Fleets, is poorly known.

(ii) Errors in identification of red hake and white hake (*Urophycis tenuis*) in the nominal landings records result in additional uncertainty in landings estimates over and above any historical inaccuracies in the overall catch reporting. Results of the length-based method applied to silver hake to split the commercial catches by species, based on research trawl data, were not used because of implausible changes to historical data in the northern region (mostly related to some years of very large landings). The nominal landings data probably capture the general trend in the fishery over time, but are subject to the uncertainties due to species misidentification.

(iii) The precision of discard estimates, which represent a significant proportion of the catch biomass, was not presented. Numbers of trips where red hake were sampled are small or zero for many fleet-year combinations. Some measure of the sampling rate by fleet (numbers of trips observed compared with total numbers of fleet trips) over time would have been informative. Even though the length-based model to estimate corrected mixed species discards was available, for consistency with the way landings were handled, the nominal discard values were used.

(iv) Sampling rates for estimating length compositions from fishery landings have been very variable with considerable pooling of data over years in the northern region. Length compositions of discards are also poorly estimated with considerable pooling across years. Numbers of trips sampled would have been useful for gauging effective sample sizes.

(v) No fishery age samples were available for inferring catches at age from catches at length.

2. *Present the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data.*

This ToR was met. The design, implementation and analysis of the NEFSC survey data were appropriate for red hake. The survey data provide valuable information on the seasonal distribution patterns and length compositions, and changes over time. Precision of the surveys was calculated but the data do not at present permit an evaluation of the assumption that trends in survey indices represent equivalent trends in stock abundance.

The assumption of constant survey catchability implicit in the use of survey indices for management is unproven for red hake. This is because there is no analytical assessment to gauge it against and no age compositions to examine internal consistency. As with all three hake stocks, the AIM method had difficulty showing that the survey indices respond in a coherent way to changes in fishing. Silver hake and red hake show similar trends in their biomass indices over time in the northern fall survey, showing the same noisy but progressive increase in catch rates over most of the series, with a sharp drop in the 2000s. This could indicate factors other than abundance affecting both stocks in a similar way. This could also imply similar patterns of recruitment, growth or consumption mortality (or a combination of these).

The proposed study on catchability of silver and offshore hake in the survey trawls could yield useful information for other co-occurring species such as red hake, for which data and analyses for ground-truthing the survey indices are limited. Many of the same issues described for silver hake will affect red hake also, such as the survey gear low headline height, relative to both the new RV (*Bigelow*) and commercial gear.

Since the change in survey vessel from R/V *Albatross* IV to R/V *Henry B. Bigelow* in 2009, a larger otter trawl with a greater vertical opening has been used. There are many other differences in vessel operation, gear and towing procedures including lower towing speed that affect the change-over in the survey time-series. Differences in catchability at length were estimated from 636 paired tows for these two vessels in 2008, indicating generally higher overall catch rates of red hake in the larger newer net except at the smallest and largest sizes during the autumn survey and site specific stations. Given the switch in research vessels during the assessment time-frame, it was necessary to take into account vessel and gear differences in catchability in the survey time-series. This was done by converting the new vessel (*Bigelow*) index into "*Albatross* equivalents".

The point was made during the review process that as time progresses this will need to be done for each successive survey and it would be better to review the survey data as a whole and convert the survey index points generated from the *Albatross* data in to "*Bigelow* equivalents". The reviewer endorses this view. After sufficient *Bigelow* years are available the data series could be split into two, an *Albatross* series and a *Bigelow* series.

The Delta method of handling the survey estimates, amplified the variability in the indices rather than dampening it. The Hake Working Group proposed that the calculation of survey indices based on arithmetic means of station catch rates within survey strata is more appropriate for this stock than the use of the delta method, particularly if the variance of log-transformed (non-zero) catch rates is poorly estimated due to small numbers of tows and high variability of catch rates within strata. The review agrees with this proposal.

3. *Evaluate the validity of the current stock definition, and determine whether this should be changed. Take into account what is known about migration among stock areas.*

I concur with the conclusion of the Hake Working Group that biological evidence for the existence of a single or two separate (northern and southern) stocks of red hake is equivocal. The split into two stocks was done with analogy to silver hake. While patterns of distribution of spawning silver hake can be inferred from the egg distributions of this species, there are three species of *Urophycis* with overlapping distributions and (currently) indistinguishable eggs from which the distribution of the individual species cannot be inferred.

4. *Estimate measures of annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.*

This ToR was met and the methods were applied in an appropriate way. Substantial exploratory work had been carried out on the age-based data for the survey, fishery and predator consumption using SS3 and SCALE but the diagnostics were not adequate for stock status determination or for the provision of management advice.

The AIM (An Index Method) was applied to evaluate if changes in relative fishing mortality (annual catch divided by the survey biomass index) led to subsequent coherent changes in survey biomass and to estimate relative F at which biomass replacement occurred. The model was applied separately to the northern and southern stocks. No significant relationship was detectable between replacement ratios and relative F, and the relationship between survey index and relative F appeared to change over time. The results suggest that factors other than fishing are affecting the survey trends, or F is too low for the fishery to have a detectable effect. The Hake Working Group chose to use a truncated time-series from 1980 onwards for evaluating BRPs, to take into account changes in predator consumption estimates (it also reduced reliance on the large landings from the early years of the fishery with its associated higher uncertainty).

Although consumption of red hake by key fish predators was not requested as part of the ToR this work was prepared as part of addressing the same issue for silver hake. For red hake, consumption in the early part of the time series (1977- 1992) was less or equivalent to the total fishery catch. This changed later in the time series such that between 1993 and 2009 consumption increased to more than six times total catches. The increased ratio is partly but not solely due to decreases in the total catch.

Various model formulations of the SCALE model were used with the northern stock, southern stock and for combined northern and southern stocks. These included different natural mortality rates, alternative catch series, and different time periods. All models responded poorly to the absence of older ages (sizes) in more recent years and lack of fit to the catch at the beginning of the time series. One model run was started from 1980 to avoid the very large early fishery catches but the model did not fit to the declining trend in catch. The model also showed a very strong retrospective pattern. Finally, as consumption cannot be added to SCALE as it is configured, it will no longer be considered as a potential candidate model for red hake assessment due to the desire to use consumption to scale M.

The forward-projecting statistical catch-at age model Stock Synthesis 3 (version 3.11c) was applied to estimate fishing mortality rates and stock sizes for the northern stock, southern stock and combined areas. Overall, there were problems in fitting stock-recruit parameters within the model, and fitting the length compositions from the different sources (survey, fishery, consumption) leading to poor model convergence. Therefore, no SS3 models were accepted at this time, although the Hake Working Group thought that it was worthwhile to pursue for the next assessment. There were clear limitations in the data (no age compositions; patchy length compositions; uncertain catches) but the SS3 approach (or a similar approach tailored to red hake) is worth pursuing. Such approaches allow for length-based processes such as fishery selectivity and predation selectivity. Revisions of data series should be carried out so that inputs reflect actual data and avoid extensive 'creation' of missing data (especially using pooled data over blocks of years to fill gaps, which can smooth out year class signals that models attempt to estimate). However, without any age composition data for the fisheries or surveys, there are likely to be continuing difficulties in finding unique solutions.

5. *State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for BMSY, BTHRESHOLD, and FMSY; and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.*

The Hake Working Group correctly stated the existing stock status definitions, and met this ToR by proposing new BRPs based on proxies of BMSY derived from the AIM.

In previous SAFE Reports, the Whiting Monitoring Committee (WMC) noted problems associated with the overfishing definition for the southern stock of red hake. Although the current definition is intended to identify overfished (i.e. low biomass) stock conditions, it is a better indication of overfishing (high exploitation rate) conditions. The WMC recommended that the overfishing definition for the southern stock of red hake be revisited after a benchmark stock assessment is completed.

New BRPs for both northern and southern red hake stocks are as follows:

> *Red hake is overfished when the three-year moving arithmetic average of the spring survey weight per tow (i.e., the biomass threshold) is less than one half of the BMSY proxy, where the BMSY proxy is defined as the average observed from 1980-2010. The current estimates of Bthreshold for the northern and southern stocks are 1.27 kg/tow and 0.51 kg/tow, respectively.*
>
> *Overfishing occurs when the ratio between catch and spring survey biomass exceeds 0.163 kt/kg and 3.038 kt/kg, respectively, derived from AIM analyses from 1980-2009.*

Applying the F_{MSY} proxy to the B_{MSY} proxy allows for an MSY of 412 mt for the northern stock and 3,086 mt for the southern stock.

The 80% confidence intervals around the F_{MSY} proxy for the north are from 0.062-0.240 kt/kg/tow and for the south are 2.240 -3.700 kt/kg/tow

6. *Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Red hake TOR 5).*

This ToR was met as the status of the stock was evaluated against the existing BRPs and newly proposed BRPs (see ToR 5).

Based on current BRPs, the northern stock of red hake is **not overfished** and overfi**shing is not occurring**. The three year delta mean biomass index, based on the NEFSC fall bottom trawl survey for 2007-2009 (2.87 kg/tow), was above the management threshold level (1.6 kg/tow) and slightly below the target (3.1 kg/tow). The three year average exploitation index (landings divided by biomass index) for 2007-2009 (0.03) was below both the target (0.39) and the threshold (0.65).

Based on current BRPs, the southern stock of red hake is also **not overfished** but **overfishing status is unknown**. The three year delta individual mean weight index, based on the NEFSC fall bottom trawl survey for 2007-2009 (0.10 kg/individual), is below the management threshold (0.12 kg/individual) but the three year average recruitment index (5.95 number/tow) is above the threshold value (4.72 number/tow).

Similarly for the newly proposed BRPs, the northern stock of red hake is **not overfished** and **overfishing is not occurring**. The three year arithmetic mean biomass index, based on the NEFSC spring bottom trawl survey for 2008-2010 (2.42 kg/tow), was above the proposed management threshold (1.27 kg/tow) and slightly below the target (2.53 kg/tow). The exploitation index (catch divided by biomass index,) for 2007-2009 (0.103 kt/kg) was below the threshold (0.163 kt/kg).

Compared with the newly proposed BRPs, the southern stock of red hake is **not overfished** and **overfishing is not occurring**. The three year arithmetic mean biomass index, based on the NEFSC spring bottom trawl survey for 2008-2010 (0.95 kg/tow), was above the proposed management threshold (0.51 kg/tow) and slightly below the target (1.02 kg/tow). The exploitation index (catch divided by biomass index, for 2007-2009 (1.150 kt/kg) was below the threshold (3.038 kt/kg).

7. *Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).*
    a. *Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).*
    b. *Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.*
    c. *Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.*

In the absence of an accepted assessment model as a basis for providing management advice, it was not possible to perform multi-year projections.

8. *Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.*

This ToR was met by reviewing previous SARC and WG research recommendations and identifying new recommendations. Most of the new recommendations made by the Hake Working Group will provide useful information to improve the assessment of red hake. One of the recommendations, that to estimate discard mortality (i.e. proportion of discarded hake that die), is not considered necessary, as the experience of commercial trawling, given longer towing time than research trawling, is that the vast majority of hake brought on board are either dead or would not survive return to the water.

Red hake recommendations

The Panel made a number of additional research recommendations:

1. Collection and analysis of suitable data to ground-truth the assumption of constant catchability in the trawl surveys for red hake. This could be embedded in a broader study of size/age related vertical distribution patterns and trawl escapement of hake (and other) stocks according to depth, area and time of year, for example using acoustics and net-mounted, upward looking transducers.

2. Consideration should be given to use of linked VMS and landings/sampling data to investigate spatio-temporal effort and CPUE, and standardized CPUE indices for vessels that fish for red hake.

3. Simpler means of providing management advice should be investigated.

4. Further work should be conducted to refine and expand the consumption estimates to include more fish and non-fish predator species, including those that may feed on older red hake.

5. Age data should be collected directly from the fishery.

CIE Reviewer red hake recommendations *(for next benchmark review).*

Red hake recommendation 1.

Review the existing length (and age?) frequency data, as these appear to be creating problems for the available assessment models. Based on the outcome of this data review, refresh the length frequency data collection program to improve data quality for the long-term for this species.

Red hake recommendation 2.

Consistently collect age (and other biological) data directly from the fishery to provide time-series suitable for supporting improved assessments.

Red hake recommendation 3.

Red and white hake (*Urophycis tenuis*) are sympatric species and co-exist over a considerable range. The confusion between these species in the catches (landings and discards) is currently inadequately addressed. This issue should be directly addressed by collecting samples through the observer program (and/or port sampling) to provide data that can be used to differentiate the catches from direct species identification from within the catches based on morphometric and/or genetic analyses. This could be part of a larger program to address Panel recommendation #4 for silver hake in the previous section above.

Red hake recommendation 4.

This repeats reviewer recommendation #1 for silver hake (above). Following the changeover to the new research vessel (*Bigelow*), the most recent survey indices have been recalculated to be equivalent to those derived using the old research vessel (*Albatross*) i.e. as "*Albatross* equivalents". While this may have be appropriate following the first surveys by the new vessel, given that all future data will be collected using the new vessel, it would be more appropriate, for the short- to medium-term, to recalculate the historic data and express them in '*Bigelow'* equivalents for future use. This should both reduce the effort required for each future survey analysis and also reduce the possibility of recalculation errors. Eventually the data from the RV *Bigelow* using the new trawl should be treated as a separate survey series for use in assessments, recognizing that catchability at length is different in the two gears.

Red hake recommendation 5.

The uncertainty of whether the red hake occurs as a single stock or two stocks is a fundamental issue that impacts the assessment and management of this species. This should initially be addressed by comparison of samples from the two areas by one or preferably more methods, including genetic comparison, preferably supported by morphometric analyses from the whole range of this species. Ideally this should form part of wider assessment of the sympatric hakes in this region.

C: offshore hake

Summary for offshore hake

This was the first assessment of offshore hake (*Merluccius albidus*). The Hake Working Group did a thorough job but the data are simply insufficient and inadequate to complete an assessment at this time. The major shortcoming is that the surveys are believed not to cover the whole stock area and thus cover an unknown and variable proportion of the stock. As a result a survey-based index is prone to considerable uncertainty.

Comments on Individual Terms of Reference: offshore hake

1. *Use models to estimate the commercial catch. Describe the uncertainty in these sources of data.*

This ToR was met in terms of reconstructing historical landings, discards and associated length and age compositions, as far as was possible with the available data. The length and depth based estimators were applied to separate offshore hake from mixed hake landings records. Fishery effort and LPUE data were not presented due to concerns over the effect of management regulations. Consideration of the commercial LPUE or CPUE may have provided an alternative abundance index to the inadequate survey index. There is no directed fishery for offshore hake, it is mostly taken as a by-catch in the silver hake fishery but individual fishing trips sometimes fish in areas where offshore hake may be the larger component of the catch.

The principal uncertainties in the fishery data include:

(i) The accuracy of the historical landings, particularly for the Distant Water Fleets, is poorly defined.

(ii) Prior to 1991, catches of silver hake and offshore hake were not reported separately. Since 1991, landings have been reported by species although the completeness of species reporting has been variable and there are some indications that the species may not be being correctly identified. The length-based and depth-based estimators used to partition the landings (and discards) based on NEFSC research survey data give inconsistent results over time. Errors in the species composition estimates are likely to have greater impact on the offshore hake catches which are considerably smaller than for silver hake.

(iii) Estimates of discards are also affected by species identification problems and are derived from mixed silver and offshore hake discard estimates. The numbers of observer trips in which silver and offshore hake have been sampled is patchy and often low, with pooling of length compositions over some years and across species.

(iv) Very few offshore hake landings have been sampled for length composition at ports, too few to consider estimating the length or age composition of the offshore hake landings.

2. *Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.*

This ToR was met. The research survey design is not appropriate to provide an index of abundance for this species as the area surveyed does not cover the stock distribution. Precision of the surveys was calculated, but potential biases in the surveys were not sufficiently addressed by the Hake Working Group.

The type of trawl gear used on the historical NEFSC trawl surveys is likely to be sub-optimal for a survey of offshore hake due to the very low headline height. The small demersal trawl on the RV *Albatross* with 1-2m vertical opening is likely to have been susceptible to large variations in capture efficiency for hake that may be related to depth, fish size, water temperature, light intensity and location of prey species in the water column. In addition, small differences in the area sampled with respect to the distribution of the stock could induce substantial changes in stock size estimates between surveys. The Hake Working Group correctly concluded that it is unlikely that the survey covers the entire distribution of offshore hake and that changes in survey abundance indices are as likely to be due to changes in fish distribution as to changes in abundance. To generate a reliable assessment of offshore hake requires increased knowledge of its distribution and either a suitable survey or alternative indices of abundance (e.g. a commercial fishery CPUE time series).

The change in survey vessel from the RV *Albatross IV* to the RV *Bigelow* since the 2009 surveys is likely to result in improved sampling of offshore hake due to the greater headline height of the gear used on the newer vessel. It has not been possible to derive conversion factors for offshore hake and thus those for silver hake have been used. While it is no longer possible to do field work to derive conversion factors directly, increased knowledge of offshore and silver hake behavior might help decide if the silver hake conversion factors are likely to be appropriate for offshore hake.

3. *Estimate measures of annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates.*

This ToR was addressed but not met by the Hake Working Group as it was not possible to derive estimates of fishing mortality, recruitment and biomass from the methods applied. Two assessment methods were attempted: AIM (An Index Method), and SEINE (Survival Estimation In Non-Equilibrium Situations Model (Gedamke and Hoenig, 2006)).

The AIM model was applied to examine relationships between relative F (catch:survey biomass index) and replacement ratios and abundance indices, using time-series of fishery landings and survey biomass indices. No significant relationship was detectable between relative F and replacement ratio. As with both silver and red hakes, the relationship between the abundance indices and relative F appeared to vary over time. This could indicate the trends in survey indices are being strongly influenced by factors other than abundance and catch, and/or that the true F is too small for any changes to have detectable effect on survey indices. An additional limitation with this analysis is the potentially large uncertainties in the estimates of offshore hake landings.

The SEINE model was applied using estimates of mean length in offshore hake survey catches above a defined length threshold. The approach allows for transitory changes in mean length to be modeled as a function of mortality rate changes. The rates of change depend on the von Bertalanffy growth parameters and the magnitude of change in the mortality rates. As there are no existing growth parameter estimates for offshore hake, the Hake Working Group used an average of southern Georges Bank and southern New England silver hake growth parameters ($L\infty = 43.91$ and $k = 0.33$). Some length at age data for offshore hake were also used for estimating VB parameters but required a forced value for asymptotic length. A range of threshold length values ($L_{critical}$) were examined for estimating mean length in the surveys, and sensitivity runs were carried out varying the VB growth parameters. The Hake Working Group found no correspondence between the mortality rate and the catch and appropriately concluded that the results from SEINE are not a reliable basis for providing management advice.

4. *State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for BMSY, BTHRESHOLD, and FMSY; and estimates of their uncertainty). If analytic model-based*

estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

This ToR was completed.

Based on the current BRPs, offshore hake is **not overfished** and the **overfishing status is unknown**. The three year delta individual mean weight index, based on NEFSC fall bottom trawl survey data for 2007-2009 (0.16 kg/individual), is below the management threshold (0.24 kg/individual) but the three year average recruitment index (0.89 num/tow) is above the threshold value (0.33 num/tow).

The overall conclusion is that adequate information is not available to determine stock status with confidence. This is because fishery data are insufficient and survey data are considered not to reflect stock trends: status is, therefore, unknown. The Panel also concluded that it was not possible to provide a reliable overfishing definition. The survey time-series is not considered to be a good index of abundance (or of mean weight) and may be driven more by changes in distribution than by changes in abundance. Therefore, no alternative BRPs could be recommended and the existing BRPs should also be rejected. Estimates of catches are highly uncertain and in the absence of a reliable index of stock size, it is not possible to construct BRPs with such data and, therefore, it is not possible to evaluate the status of the stock. If a reliable index of stock size were available, e.g. from a time-series of commercial CPUE, and if the uncertainty in catches could be reduced, the ratio of catch to index might be a better measure of overfishing than using mean weight.

5. *Evaluate stock status (overfishing and overfished) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Offshore hake TOR 4).*

This ToR was completed. No new BRPs are proposed (see comments on ToR #4 above), but the ToR was addressed.

6. *If a model can be developed, conduct single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).*

    a. *Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).*
    b. *Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.*
    c. *Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.*

This ToR was addressed, but a usable model could not be developed because of insufficient or inadequate data and because the survey does not cover the entire stock area and, therefore, changes in the survey estimates could represent changes in availability in the survey area rather than real changes in abundance. Developing annual catch limits will be impossible given that the landings cannot be reliably separated. The major source of uncertainty is the mixed reporting of silver and offshore hake landings.

7. *Propose new research recommendations.*

This ToR was met by reviewing previous SARC and WG research recommendations and identifying new recommendations. Given the effective data poor status of offshore hake, most of the new recommendations made by the Hake Working Group will provide useful information to improve the future assessment of offshore hake, but the prioritization should be reconsidered following this review. As was the case for the other hake species reviewed, the recommendation to estimate discard mortality (i.e. proportion of discarded hake that die), is not considered necessary, as the experience of commercial trawling, given longer towing time than research trawling, is that the vast majority of hake brought on board are either dead or would not survive return to the water.

Offshore hake recommendations

The Panel made the following additional research recommendations:

1. Design and execute a survey to evaluate the area of distribution of offshore hake using appropriate methods and fishing gear. Such a survey would also be useful to estimate the offshore extent of silver hake.

2. Investigate the possibility and usefulness of modifying the port sampling protocols in order to better estimate the catch of offshore hake.

3. Design a program to collect information from the commercial fishery in deeper waters to get a better idea of the depth distribution and biological information for of offshore hake.

4. Assign a code for reporting offshore hake.

5. The Panel recommends that simpler means of providing management advice be investigated.

CIE Reviewer offshore hake recommendations *(for next benchmark review).*

Offshore hake recommendation 1.

Develop one or more time-series of effort, LPUE (or CPUE) from the commercial fleet or fleets and evaluate their applicability as indices of abundance as an input to the next assessment.

Offshore hake recommendation 2.

Upgrade the quantity and quality of biological data (age, length, weight sex, reproductive stage, etc.) that is collected for this species from the fishery, as well as from the research surveys. Data from the fishery are likely to prove more important in future assessments due to its direct applicability to the landings.

Offshore hake recommendation 3.

Develop a substantive time-series of discard data from the fishery.

D: Longfin squid (*Loligo pealeii*)

Summary for *Loligo*

The majority of the Panel considered the data and assessment for *Loligo* provide an appropriate basis for developing management advice for this stock. This reviewer differs from this view, principally because of how the two, largely separate, cohorts with a lifespan of less than one year were handled within a set of ToR and approach to assessment and management that was highly annualized.

This reviewer considers that the apparent success of the current approach to assessing and managing this stock has been fortuitous, based on reasonable recruitments and a relatively low level of exploitation. The setting of an annual allowable catch for a species with two largely separate cohorts each year will inevitably mean that in years (seasons) of low abundance the catch limit may not be low enough to protect the stock from overexploitation, and in years of high abundance the fishery will miss out of potentially large catches. For an annual species (all ages <1 year and where there is effectively no standing stock passing from year to year) overfishing in seasons of low abundance may be critical to subsequent spawning and the next recruitment. It is recognized that squid populations can be highly productive and are able to quickly recover from being overfished.

The assessment of *Loligo* reviewed is a model-free approach, based on trends in biomass estimates from the NEFSC spring and fall surveys. Possible ranges for absolute biomass each year are investigated by establishing feasible ranges for catchability in the surveys according to trawl deployment parameters and capture efficiency. The resultant biomass estimates are compared with fishery catches and estimates of consumption by a subset of fish predators sampled for diet composition during the NEFSC surveys. The results were used to establish biological reference points for biomass and to infer the possible magnitude of exploitation rate.

The main conclusion of the assessment is that the annual average biomass estimates from the surveys are much larger than the fishery catches, even when calculated using the largest feasible catchability values for the surveys, and that the biomass has fluctuated without trend since the late 1970s and is currently above the proposed B_{msy} threshold. However, the assertion of the Invertebrate Working Group that the efficiency of the survey trawl is the same in fall and spring, and hence that the 5-fold difference in catch rates represents equivalent differences in biomass, is a less robust conclusion and requires further analysis. Moreover, the averaging of the biomass estimates for the two within-year cohorts is inappropriate, this is because they are at best weakly linked and the drivers of population size may be completely different for different cohorts (food availability, temperature, predation pressure, etc.). Ideally each cohort should be considered separately, or if annual production is required they should be summed.

Better understanding and modeling of seasonal cohort recruitment, growth, mortality, catch, effort and age would allow possibilities for within-season, or, at least, within year, assessment and management schemes to be explored.

Comments on Individual Terms of Reference: *Loligo*

1. *Characterize the commercial catch including landings, effort, LPUE and discards. Describe the uncertainty in these sources of data.*

This ToR was met to the extent possible given the available data, and that the commercial fishery data from 1987 onwards are appropriate for inclusion in the assessment of the stock.

Landings statistics were presented from 1963 to 2010, including Distant Water Fleet (DWF) landings from 1964 to 1986. Squid landings were not recorded by species until 1979; prior to that, landings were estimated by pro-ration. Since 1979, a portion of the US squid landings have been reported as unspecified squid species. Unspecified squid landings for 1982-1995 were pro-rated and these landings were included in the assessment. Unspecified squid landings reported from 1996 onwards have been much lower.

Discard data were presented for 1963 to date; however, discard data were only collected from fishing vessels by the Northeast Fishery Observer Program since 1989. *Loligo* discards and their precision were estimated using standard methodology during 1989-2009. Estimated catch for the period 1963-2010 ranged between 595 and 38,892 mt, peaking in 1973 when the DWF was operating. Catches have declined since 2005 and reached a minimum of 9,560 mt in 2009, the decline appearing to be related to in-season management.

It is acknowledged that landings data prior to 1987 are uncertain and discards, although representing a small portion of the total, were not estimated directly. As a result, total catches prior to 1987 are uncertain and, therefore, the assessment focuses on catches during 1987-2009. The inshore fishery is on spawning aggregations, mature females have not been identified in the offshore fishery.

Effort trends were presented by 6-month period showing a declining trend in the first half of the year compared to the 2nd half where effort has remained quite stable. This pattern could be related to seasonal closures.

Landings-per-unit-effort (LPUE) data were presented but not used in the assessment because it was considered that they may not be indicative of stock abundance for schooling organisms such as *Loligo*. This is probably incorrect as CPUE data are used in the assessment and management of other squid species including other *Loligo* species (Agnew *et al*. 2007; Beddington, *et al.* 1990; Rosenberg *et al.* 1990).

LPUE in the 1st half of the year is approximately the same, on average, as the LPUE in the 2nd half of the year. There was agreement within the Panel that the fishery LPUE data should be explored in more depth in relation to the apparent 5-fold difference in survey catch rates between spring and fall.

The length frequency data collected since 1987 are of variable quality, with improved sampling since 1996. The data are adequate for characterizing the size composition of the catches, indicating full recruitment at around 12cm dorsal mantle length (DML). Discards typically average 5-8cm DML with variation considered to be related to the timing of fishery closures. A figure of 8cm DML is used in the assessment to separate catches into recruits and pre-recruits, which appears to be a reasonable figure to use.

The characterization of LPUE (or CPUE) was appropriate for the annual assessment presented but given the very short life-span of this species presentation of CPUE and LPUE on a much shorter (e.g. weekly) timeframe would also have been more useful to understand the fishery. An example of such data was made available to the Panel upon request.

The LPUE presented was based on landings in weight. Given the very rapid growth exhibited by squid (e.g. a five-fold season increase for *Illex argentinus*), weight-based LPUE across the season can be misleading. Therefore, in addition to weight based LPUE, LPUE based on numbers should also be available and requires regular length weight sampling over the season from the fishery.

Given improved measurement of discards, the reviewer would prefer to see CPUE rather than LPUE used as this then include all fishery removals.

The principal uncertainties in the fishery data include:

(i) The accuracy of the historical landings as a result of the DWF operations between 1964 and 1986, and also the combined species reporting up to 1979 and how these were pro-rated.

(ii) The accuracy of the estimation of historic discards.

2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.

This ToR was met. The design, implementation and analysis of the NEFSC survey data were appropriate for *Loligo*, with the exception of possible issues with coverage of the offshore extent of the population in spring and the adequacy of the gear (low headline height for the RV *Albatross* data). The Invertebrate Working Group provided information on seasonal and inter-annual patterns of distribution and length structure. Precision of the surveys was calculated and plausible ranges for catchability components were developed to convert swept-area catch rates into biomasses. However, the upper limits for biomass are poorly defined due to lack of data on trawl capture efficiency (i) across the depth range inhabited by *Loligo* and (ii) where high densities of squid, particularly in years of high abundance, may lead to more squid being off the seabed and above the headline height.

Catchability-adjusted swept-area biomass, computed from NEFSC spring (March-April) and fall (September-October) bottom trawl surveys, and seasonal and annual exploitation indices (NEFSC 2002) were used to assess the stock. In order to annualize the biomass estimates for the seasonal cohorts tracked by these surveys, annual averages of the fall and spring bottom biomass estimates were computed for 1976-2009. Given the short life span of squid, the Panel considers that it may be more appropriate to estimate seasonal indices. The argument of this is the, at best, weak link between the size of, for example, the spring cohort in one year and the spring cohort in the next year. Thus, the influence of past biomass estimates on the current population is virtually nil, which is very different from most finfish stocks. There is a second issue to consider in the averaging of the two cohort biomasses for each year: as these are believed to be largely separate cohorts, the appropriateness of averaging them is flawed, these quantities should be summed.

The survey catchability was estimated as a composite prior derived from field measurements of the factors influencing catchability. The importance of uncertainty in bounds was reduced because the bounds have a probability near zero. The most important parameter for evaluating potential exploitation rates is q_{max}, which gives the minimum biomass estimates and maximum exploitation rates. This parameter is estimated with high precision (CV 0.03). However, the minimum catchability is uncertain as the lower bound of the efficiency of capture is unknown. Hence the upper limits of biomass estimates (and the median biomass) are effectively undefined.

Only day-time trawls were used to derive survey indices because the capture efficiency of bottom trawls is highest for *Loligo* during the day (Sissenwine and Bowman 1976; Brodziak and Hendrickson 1999) resulting in reduced CVs. Comparison between the biomass estimates from the fall and spring surveys suggests higher productivity in autumn, as seen in other loliginid fisheries. The Panel considered that the low catch rates in spring, when the squid are distributed mainly in deep water towards the shelf edge, could be the result of squid being more widely dispersed in the water column and less available to the gear than would be the case during fall when the squid are widely distributed across most of the shelf.

The squid distribution in the water column extends well above the headline height of the survey net, particularly before the introduction of the RV *Bigelow*. Squid also tend to show increased vertical distribution in the water column as their density increases, such that in seasons of high abundance the tendency for the gear to underestimate abundance may be exacerbated. This creates uncertainty in the fraction of squid that is available to the gear and thus in biomass estimation.

Annual biomass estimates exceed the estimated annual carrying capacity in multiple years. This probably reflects mismatches between the ideas of carrying capacity as a static value and the highly variable population size in squid, or may also be because the carrying capacity has been underestimated. It is not unexpected for a species with highly variable seasonal population dynamics that are linked to variability in environmental conditions to exceed an estimated carrying average capacity as in reality the carrying capacity between years will be different.

The Panel requested a correlation matrix between survey indices (8 cm or less (pre-recruits) and more than 8 cm (recruits)) indices within survey and between subsequent surveys. Both mean number and kg per tow indices were significantly correlated for spring and fall surveys carried out in the same year. Correlations between pre-recruits and recruits were only significant for same year spring survey estimates.

3. *Estimate annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates (consider Loligo TOR-4). Include a historical retrospective analysis to allow a comparison with previous assessment results.*

This ToR was addressed within the limitations associated with the short-lived characteristics of species. The historic biomass and recruitment proxies were provided by the survey estimates. No modeling of the population dynamics was attempted for this assessment. The Panel considered the analyses suitable for providing relative trends in biomass and for evaluating the potential magnitude of biomass in relation to catches and consumption estimates.

Estimates of fishing mortality were approximated by the exploitation rate, computed as the ratio of the annual catch over catchability-adjusted mean biomass as estimated by the fall and spring surveys. The Invertebrate Working Group calculated exploitation indices using all sizes of squid in the surveys rather than just the recruited sizes (> 8 cm DML). This is probably not critical if the relative trends over time are the main interest. However, the ratio of fishery catch weight (dominated by the much heavier recruited animals) to survey biomass (dominated by relatively light pre-recruits) is difficult to interpret in absolute terms unless numbers rather than weight are considered.

Survey indices were provided by DML in two groups: pre-recruits (<= 8cm) and recruits (> 8 cm). Given the protracted spawning season and subsequent overlap of fast growing sub-cohorts the recruit index was not used as indicative of year-class strength. Survey catchability for the pre-recruits appears to be less than for recruits and is likely to increase the uncertainty in the estimates of the pre-recruits.

Survey estimates of annual and seasonal stock biomass were compared with catches and consumption estimates. Concerns were raised that the biomass series could change in future with adjustments of the survey catchability, q. The Panel therefore requested that a plot of annual mean biomass relative to the proposed BMSY threshold should be supplied.

Comparisons with previous assessment results, which included production modeling approaches, were not considered because of differences in computation methodology and input data. However, given that the assessment is model free no retrospective bias was expected.

No population model was attempted therefore no estimates of absolute biomass or fishing mortality are available.

4. *Summarize what is known about consumptive removals of Loligo by predators and explore how this could influence estimates of natural mortality (M).*

This ToR was met. Consumption estimates are extremely useful for demonstrating the potential magnitude of predation as a significant factor in natural mortality and the importance of *Loligo* in the ecosystem, despite the biases acknowledged by the Invertebrate Working Group.

Preliminary estimates of the seasonal consumption of each of the two *Loligo* cohorts were computed using food habits data collected during the 1977-2009 NEFSC spring and fall surveys.

Consumption estimates are considered to be:

i. minimum, because they only relate to 15 predatory fish and do not include cetaceans, birds, large pelagic fish species, invertebrates (e.g. squid, including cannibalism) or pinnipeds;
ii. preliminary, because the ecosystem and predator dynamics in relation to the complex and high turnover rates of squid populations are poorly understood.

The Invertebrate Working Group estimated spawning natural mortality (M_{sp}) of 0.11 per week and non-spawning natural mortality (M_{ns}) of 0.19-0.48 per week for *Loligo* using the methods of Hendrickson and Hart (2006) and the gnomonic method of Caddy (1996), respectively. These were similar to estimates for another northwest Atlantic squid species. The Panel considered that these methods were only approximate but that such high mortality rates are expected as *Loligo* has a short lifespan, with rapid cohort turnover rates and increased post-spawning natural mortality. Most of the natural mortality is expected to be due to predation and even post-spawning mortality may be attributed to some degree to predation, if, for example, susceptibility increases. In the absence of a population model, the estimates of predation cannot be directly compared with the M estimates. However the consumption estimates were 0.8 to 11 times the annual catches during 1977-2009, indicative of a relatively high M.

Minimum consumption estimates showed highly inter-annual variability and were 0.8 to 11 times higher than annual catches during 1977-2009. These figures suggest that squid is highly productive but this could also indicate that the biomass is underestimated by the assessment.

5. *State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and F_{MSY}; and estimates of their uncertainty). Comment on the scientific adequacy of existing BRPs and for the "new" (i.e., updated, redefined, or alternative) BRPs.*

This ToR was met.

There are no existing BRPs points for *L. pealeii*. The approach to estimate the current Fmsy proxy was considered inappropriate. The Panel requested an update of the exploitation rate reference point developed in the previous assessment.

A new biomass target (50% of carrying capacity, K) and threshold (25% of K) were proposed on the assumption that the stock is lightly exploited and that annual averages of the spring and fall biomass estimates for 1976-2008 would correspond to 90% of K. The proposed BRPs were considered scientifically defensible given the nature of the assessment based on direct estimates of biomass. The Panel had mixed views about the appropriateness of this approach, with the majority having some doubts about its applicability.

Previous estimates of Fmsy proxy based on yield per recruit analysis appeared too high compared with historic estimates. This is probably related to the lack of contrast in the data and the lack of evidence that fishing has impacted the average annual stock biomass during the period of exploitation considered (although the average annual biomass is a fairly meaningless statistic, as discussed above). Therefore, and as the above considerations still apply, a new F_{MSY} proxy could not be recommended. Previous squid assessment for northern short fin squid (*Illex illecebrosus*) and market squid (*L. opalescens*) have considered $F_{40\%}$ an appropriate proxy for F_{MSY}, an approach has also been used successfully for managing other North American squid fisheries (Report of the Stock Assessment Review (STAR) Panel for Market Squid (2001), Appendix 3 and SARC 37 Consensus Summary for Northern Shortfin Squid).

SARC 37 (2003), when assessing northern shortfin squid, stated that the best available estimates of $F_{40\%}$ and $F_{50\%}$ were based on a new per-recruit model used in the assessment but recognised that there was uncertainty regarding the underlying biological parameters which were estimated in the maturity-natural mortality model. SARC 37 also noted that the relationship of F40% or F50% reference points to F_{MSY} was unknown and an important topic for future research.

The state of the stock in respect to overfishing was evaluated relative to the 1987-2008 median exploitation index. This was computed as the ratio of the annual catch to the two-year moving average of the spring and fall survey biomass. Using a two-year average was considered necessary to smooth noisy annual survey estimates. The Panel discussed the validity of averaging in this way, as it draws together four separate cohorts over two years when the relationship between the population size of the various cohorts is unknown. This approach to averaging across cohorts and years is inappropriate, as the drivers of each cohort size may be completely different, as discussed above.

6. *Evaluate stock status with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Loligo TOR 5).*

This ToR was met. Stock status was evaluated only in respect to the "new" BRPs because biomass reference points did not exist and the existing F_{MSY} proxy was considered not appropriate for a lightly exploited stock such as *L. pealeii*. In addition, the exploitation indices from the current assessment were not comparable with previous estimates. However, and only for completion, the Panel requested updating of the existing F_{msy} proxy.

Determination of current stock status relative to reference points was based directly on survey estimates adjusted by the estimate of catchability q. The WG focused primarily on the estimation of the catchability upper bound q_{max}. This was directly estimated based on mean values to minimize associated variance.

The determinations that during 2009, the *L. pealeii* stock was **not overfished** and **overfishing was *probably* not occurring** are based on the two-year average of catchability-adjusted spring and fall survey biomass levels during 2008-2009 (at 54,618 mt was higher than a proposed threshold B_{msy} proxy of 21,203 mt) which is based on the erroneous averaging of different populations with little, if any, linkage, and so is inappropriate. There are no existing biomass reference points for comparison.

The stock appears to be lightly exploited because annual catches were low relative to annual estimates of minimum consumption by a subset of fish predators. The determination that the stock appears to be lightly exploited because there was no evidence of fishing effects on annual survey biomass estimates (i.e. annual averages of the spring and fall biomass estimates) during 1975-2009 is erroneous. Fishery removals would not be detectable in the same season from a 'point' estimate which the survey effectively takes. Moreover, the effect of fishing on the stock in the following year would also not be expected to be visible, unless the stock had been grossly depleted and insufficient spawner escapement was left at the end of the season.

The 2009 exploitation index (catch in 2009 divided by the average of the spring and fall survey biomass during 2008-2009; 0.176, 80% CI = 0.124-0.232) was slightly below the 1987-2008 median (0.237) but is inappropriate for the reasons outlined above.

7. *Develop approaches for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs), and comment on the ability to perform projections for this stock.*

This ToR was met. Approaches for computing candidate ABCs were considered appropriate by the majority of the Panel. Similarly the majority of the Panel considered the omnibus approach as flexible and as' may well' be a sufficient basis for specifying ABC levels for the *Loligo* fishery.

The application of an ABC may protect the stock in years of moderate to good recruitment but is unlikely to do so in years of poor or very poor recruitment (where recruitment is principally driven by adverse environmental conditions). This should not be described as sub-optimal, as it clearly takes undefined risk with the stock. If this approach to management is followed, then this risk should be fully quantified. Moreover, in years of above average recruitment much of the squid that is available to harvest will go un-harvested under a pre-determined ABC.

A more precautionary approach, retaining the use of a defined biological catch (in this case a Seasonal Biological Catch), could be developed by considering of the differences in seasonal cohort productivity and biomass. *Loligo* biomass and productivity appear to be substantially lower for the spring cohort fishery than for the fall cohort fishery but this may be an artifact caused by lower catchability in the spring survey. The relative abundance indices from the spring and fall surveys are correlated. Consideration of fishery derived CPUE series may be able to shed some light on this, as they will not suffer the same problems as the survey, especially if the index fleets are carefully selected (e.g. by area fished).

Computation of ABC by analogy to consumption estimates for key predators was considered.

Stock size projections were not possible for this semelparous, sub-annual species, because:

- this is a short-lived species, so the stock biomass in any year consists of sub-annual cohorts;
- recruitment is highly variable and strongly influenced by environmental conditions, and
- there is currently no suitable projection model for *Loligo*.

8. *Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.*

This ToR was met. Previous research recommendations were reviewed. It was noted that research recommendations were generally addressed unless subsequent developments indicated that they were no longer relevant. The recommendations contained in the assessment report were endorsed by the Panel and some new research recommendations were identified.

***Loligo* recommendations**

The Panel made the following additional research recommendations:

1. Priority should be given to modeling the population dynamics of this short-lived species. Depletion models should be considered if short-time steps abundance indices (e.g. weekly) could be constructed and fit to a seasonal cohort dynamics model (Basson *et al*. 1996; Beddington *et al*. 1990; and Rosenberg *et al*. 1991). Likewise, a two-step biomass model

of the like developed to assess the South African chokka squid (Roel and Butterworth 2000, Glazer and Butterworth 2006) could be attempted.

2. In all analyses of LPUE or CPUE include estimation by numbers as well as by weight.

3. Collection of data to clarify the seasonal signal on egg production and sexual maturation.

4. Age determination of samples collected on appropriate time intervals could help clarifying the dynamics of the so called "micro-cohorts".

5. Evaluate the proportion of squid biomass that is higher in the water column than the opening of the net.

CIE Reviewer longfin squid recommendations *(for next benchmark review).*

The following recommendations are principally focused on addressing the priority of modeling the *seasonal* population dynamics of this short-lived species. Better understanding and modeling of seasonal cohort recruitment, growth, mortality, catch, effort and age would allow possibilities for within-season, or at least, within year, management schemes to be explored.

Loligo *recommendation 1*.
Develop a seasonal program to collect biological data (length [DML], weight, sex, reproductive stage, and age in order to elucidate a more complete understanding of the cohort structure of this species over, at least, a one year period.

Loligo *recommendation 2*.
Depletion models should be considered when short-time step abundance indices (e.g. weekly) become available and fit to a seasonal cohort dynamics model (Basson *et al*. 1996; Beddington *et al*. 1990; and Rosenberg *et al*. 1991). These can be developed and tested on historic data and could be developed fairly rapidly.

Loligo *recommendation 3*.
Pre-recruit/new recruit surveys of squid stocks have been used to define the initial allowable catches within year in the fishery for *Illex argentinus* on the Patagonian shelf. The NEFSC surveys occur in mid-season for *L. pealeii*. Consideration should be given to whether the NEFSC survey biomass estimates could be used to derive an allowable catch for that season which could then be used to adjust up or down an existing pre-determined allowable catch for each season while fishing is in progress. This would clearly work better if the surveys could be brought forward earlier in the season and provided that some of the concerns about the survey methodology can be adequately addressed. This would give a large measure of control and protection to the squid stock in years of poor recruitment and may also permit fuller exploitation of the stock in years of high abundance, provided that by-catch of other species is not a limiting factor.

Loligo *recommendation 4*.
Should depletion modelling (Recommendation 2) be supported by the magnitude of the impact of the fishery on the squid population (i.e. to cause measurable depletion) or early season survey based biomass estimates (Recommendation 3) be possible, then consideration of whether it is possible and how to achieve a move to within season (or at least, within year) management of squid could be achieved.

Loligo *recommendation 5*.

Collect individual length and weight data from the fishery on a short time-frame (e.g. weekly) basis in order to support a short time-step (e.g. weekly) CPUE analysis by numbers.

Loligo *recommendation 6*.

There was agreement within the Panel that the fishery LPUE data should be explored in more depth in relation to the apparent 5-fold difference in survey catch rates between spring and fall.

Loligo *recommendation 7*.

Evaluate applying alternative, in-season modeling approaches:

a. Review historic in-season CPUE (or LPUE) patterns over previous years to (i) better describe the fishery; (ii) enable an evaluation of whether alternative models (e.g. depletion models) would be a usable tool to assess squid stocks in their separate cohorts.

b. Create CPUE (or LPUE) series using one or more fleets. Review the fleet composition to establish consisted fleet composition for the development of in-season index fleets (there does not need to be between season or between year fleet consistency). The index fleets do not need to include all of the catch but do need to be representative of the fishery.

c. If population abundance and biomass can be calculated for the end of each season and back-calculated for the beginning of each season, construct and model the stock recruitment relationship.

Loligo *recommendation 8*.

Evaluate the efficiency of the bottom trawl used for the survey in catching squid off the bottom in various circumstances of depth, squid density, time of day (day light), with for example a headline-mounted upward looking acoustic echo-sounder.

Conclusions from SARC 51

All assessment teams were professional and diligent in addressing their ToR and only a few lesser elements lacked complete coverage.

The Panel was unanimous in its final evaluations of the presented models for all hake species and in selection of preferred versions. There were no significant disagreements between the Review Panel and either of the technical stock assessment teams working on hake.

There was some disagreement within the Review Panel concerning the appropriateness of the approach to assessing *Loligo*: this reviewer in particular had a number of views that differed from other Panel members and from some of the assessment team and stems from detailed knowledge based on the reviewer's active involvement in the near-real time management of squid fisheries. This minor professional divergence in views on the approach was handled by all in a completely appropriate, friendly and constructive manner.

Overall the outcome of this wide ranging review is very positive, with much endorsement for the assessment teams, and some useful areas for attention going forward.

The assessments were able to generate some management advice for most stocks.

Most, but not all, of the recommendations presented in this individual report also appear in the *Summary Report*.

Appendix 1: Bibliography (key, partial)

SARC 51
Silver hake, red hake, offshore hake and *Loligo* squid
SARC 51Review Reference List

Draft Assessment Reports		
Silver hake WP#1 (Assessment)	A. Silver Hake Stock Assessment for 2010	Hake Working Group 11/19/2010
Loligo WP#1 (Assessment)	B. *Loligo pealeii* Stock Assessment Report for 2010	SAW51 Invertebrate Working Group 11/15/2010
Red hake WP#1 (Assessment)	C. Red Hake Stock Assessment Report for 2010	Hake Working Group 11/19/2010
Offshore hake WP#1 (Assessment)	D. Offshore Hake Stock Assessment for 2010	Hake Working Group 11/15/2010
Key Reference Documents		
Fisheries Research 35(1998).155–169	Approaches to assessing stocks of *Loligo gahi* around the Falkland Islands.	Agnew D.J., Baranowski, R., Beddington, J.R., des Clers, S. and Nolan, C.P. (1998)
Fisheries Research 78 (2006) 4–13	An age-based cohort model for estimating the spawning mortality of semelparous cephalopods with an application to per-recruit calculations for the northern shortfin squid, *Illex illecebrosus*.	Hendrickson, L.C. and Hart D. R. (2006).
Fisheries Research (Amsterdam) 70 (2-3):299-310.	A multispecies approach to subsetting logbook data for purposes of estimating CPUE.	Stephens, A., and MacCall, A. (2004).
NMFS/NEFSC, Reference Document 06-22.	The analytic component to the standardized bycatch reporting methodology omnibus amendment: sampling design and estimation of precision and accuracy.	Wigley, S. E., Rago, P. J., Sosebee, K. A. and Palka, D. L. (2006).
Fish. Res. 104, 100-110.	The daily egg production method: A valid tool for application to European hake in the Bay of Biscay?	Murua, H., Ibaibarriaga, L., Álvarez, P., Santos, M., Korta, M., Santurtun, M., Motos, L. (2010)
Fish. Res., 28:3-27.	Assessment and management techniques for migratory annual squid stocks: the *Illex argentinus* fishery in the southwest Atlantic as an example.	Basson, M., J.R. Beddington, J.A. Crombie, S.J. Holden, L.V. Purchase and G.A. Tingley. (1996).
Fish. Res., 8:351-365.	Stock assessment and the provision of management advice for the short fin squid fishery in Falkland Island waters.	Beddington, J.R., A.A. Rosenberg., J.A. Crombie and G.P. Kirkwood. (1990)
	Estimating mortality from mean length data in non-equilibrium situations, with application to the	Gedamke, T. and J.M. Hoenig. (2006)

	assessment of goosefish. Trans. Amer. Fish.	
ICES CM 2009/ACOM:40. 43 pp.	Report of the Workshop on methods to evaluate and estimate the precision of fisheries data used for assessment (WKPRECISE), 8-11 September 2009, Copenhagen, Denmark.	ICES (2009).
Fish. Res. 8:335-350.	The assessment of stocks of annual squid species.	Rosenberg, A.A., Kirkwood, G.P., Crombie, J. and Beddington, J.R. (1990)
Fish. Res. 48, 213–228.	Assessment of the South African chokka squid *Loligo vulgaris reynaudii*. Is disturbance of aggregations by the recent jig fishery having a negative impact on recruitment?	Roel, B.A., Butterworth, D.S., (2000).
Northeast Fisheries Science Center Reference Document 06-05	A Historical Perspective on the Abundance and Biomass of Northeast Demersal Complex Stocks from NMFS and Massachusetts Inshore Bottom Trawl Surveys, 1963-2002	Sosebee, K.A. and Cadrin, S.X. April 2006
Northeast Fisheries Science Center	Biology and Life History of Offshore Hake (*Merluccius albidus*)	Traver,M.L., Alade, L. and Sosebee, K.A.
New England Fishery Management Council	2003 Small Mesh Multispecies Stock Assessment and Fishery Evaluation (SAFE) Report	Whiting Plan Development Team (PDT) Report October 16, 2003
Northeast Fisheries Science Center Reference Document 96-05h	*A Report of the 21st Northeast Regional Stock Assessment Workshop* 21st Northeast Regional Stock Assessment Workshop (21st SAW) 1996.	

Some additional, particularly graphic, material was presented during the meeting, either at the request of the Panel or because the technical teams considered that it would be helpful to address a specific issue. This material was all efficiently placed on the ftp server for the Panel and workshop participants to access.

Appendix 2: Statement of Work

Statement of Work
(T020-07, final 01 August 2010)

External Independent Peer Review by the Center for Independent Experts

51st Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Silver, Red, and Offshore hakes, and *Loligo* squid.

Statement of Work (SOW) for CIE Panelists
(including a description of SARC Chairman's duties)

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description The purpose of this meeting will be to provide an external peer review of benchmark stock assessments for two stocks of silver hake (*Merluccius bilinearis*), two stocks of red hake (*Urophycis chuss*) offshore hake (*Merluccius albidus*), and longfin squid (*Loligo pealeii*). Hake aggregate in large numbers, swim fast, and prey on fish, crustaceans and squid. This review determines whether the scientific assessments are adequate to serve as a basis for developing fishery management advice. Results of this review will form the scientific basis for fishery management in the northeast region. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**. The SARC Summary Report format is attached as **Annex 4.**

The SARC50 review panel will be composed of three appointed reviewers from the Center of Independent Experts (CIE), and an independent chair from the SSC of the New England or Mid-Atlantic Fishery Management Council. The SARC panel will write the SARC Summary Report and each CIE reviewer will write an individual independent review report.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the assessment of pelagic stocks and with analyses of survey catchability, particularly for the inclusion of environmental covariates. For the hakes there are concerns about stock structure, and some issues of species identification in commercial landings (e.g., offshore hake sometimes classified as silver hake). Reviewers should be familiar with methods of stock identification and indirect methods for imputing catch composition (e.g., finite mixture distribution methods). For both *Loligo* and offshore hake, experience with methods for assessing data poor stocks is desirable. Familiarity with the squid life history and the implications of temporally varying natural mortality and growth on population dynamics is also desirable.

In general, CIE reviewers for SARCs shall have working knowledge and recent experience in the application of modern fishery stock assessment models. Expertise should include statistical catch-at-age, state-space and index methods. Reviewers should also have experience in evaluating measures of model fit, identification, uncertainty, and forecasting. Reviewers should have experience in development of biological reference points that includes an appreciation for the varying quality and quantity of data available to support estimation of biological reference points.

Each CIE reviewer's duties shall not exceed a maximum of 16 days to complete all work tasks of the peer review described herein.

Not covered by the CIE, the SARC chair's duties should not exceed a maximum of 16 days (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; several days following the open meeting for SARC Summary Report preparation).

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting scheduled in Woods Hole, Massachusetts during 29 November through 3 December, 2010.

Charge to SARC panel: The panel is to determine and write down whether each Term of Reference of the SAW (see **Annex 2**) was or was not completed successfully during the SARC meeting. To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. Where possible, the chair shall identify or facilitate agreement among the reviewers for each Term of Reference of the SAW.

If the panel rejects any of the current Biological Reference Point (BRP) proxies for B_{MSY} and F_{MSY}, the panel should explain why those particular proxies are not suitable and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs are the best available at this time.

Statement of Tasks:

1. Prior to the meeting

(SARC chair and CIE reviewers)

Review the reports produced by the Working Groups and read background reports.

Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein:

Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email, and FAX number) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide by FAX the requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Approximately two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

2. During the Open meeting

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

(SARC chair)

Act as chairperson, where duties include control of the meeting, coordination of presentations and discussion, making sure all Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion. For the assessment, review both the Assessment Report and the draft Assessment Summary Report.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to discuss the stock assessment and to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

(SARC CIE reviewers)

For each stock assessment, participate as a peer reviewer in panel discussions on assessment validity, results, recommendations, and conclusions. From a reviewer's point of view, determine whether each Term of Reference of the SAW was completed successfully. Terms of Reference that are completed successfully are likely to serve as a basis for providing scientific advice to management. If a reviewer considers any existing Biological Reference Point proxy to be inappropriate, the reviewer should try to recommend an alternative, should one exist.

During the question and answer periods, provide appropriate feedback to the assessment scientists on the sufficiency of their analyses. It is permissible to request additional information if it is needed to clarify or correct an existing analysis and if the information can be produced rather quickly.

3. After the Open meeting

(SARC CIE reviewers)

Each CIE reviewer shall prepare an Independent CIE Report (see **Annex 1**). This report should explain whether each Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified above in the "Charge to SARC panel" statement.

If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent CIE Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the Independent CIE Report produced by each reviewer.

The Independent CIE Report can also be used to provide greater detail than the SARC Summary Report on specific Terms of Reference or on additional questions raised during the meeting.

(SARC chair)
The SARC chair shall prepare a document summarizing the background of the work to be conducted as part of the SARC process and summarizing whether the process was adequate to complete the Terms of Reference of the SAW. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the SARC Summary Report (see **Annex 4**).

(SARC chair and CIE reviewers)
The SARC Chair and CIE reviewers will prepare the SARC Summary Report. Each CIE reviewer and the chair will discuss whether they hold similar views on each Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each Term of Reference of the SAW, either as part of the group opinion, or as a separate minority opinion.

The SARC Summary Report (please see **Annex 4** for information on contents) should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, this report should state why that Term of Reference was or was not completed successfully. The Report should also include recommendations that might improve future assessments.

If any existing Biological Reference Point (BRP) proxies are considered inappropriate, the SARC Summary Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRP proxies are the best available at this time.

The contents of the draft SARC Summary Report will be approved by the CIE reviewers by the end of the SARC Summary Report development process. The SARC chair will complete all final editorial and formatting changes prior to approval of the contents of the draft SARC Summary Report by the CIE reviewers. The SARC chair will then submit the approved SARC Summary Report to the NEFSC contact (i.e., SAW Chairman).

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting at the Woods Hole, Massachusetts during November 29 through December 3, 2010.
3) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than December 17 2010, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to David Sampson, CIE Regional Coordinator, via email to *david.sampson@oregonstate.edu}*. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

25 October 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
15 November 2010	NMFS Project Contact will attempt to provide CIE Reviewers the pre-review documents by this date
29 Nov. – 3 Dec. 2010	Each reviewer participates and conducts an independent peer review during the panel review meeting in Woods Hole, MA
2-3 December 2010	SARC Chair and CIE reviewers work at drafting reports during meeting at Woods Hole, MA, USA
17 December 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
20 December 2010	Draft of SARC Summary Report, reviewed by all CIE reviewers, due to the SARC Chair *
29 December 2010	SARC Chair sends Final SARC Summary Report, approved by CIE reviewers, to NEFSC contact (i.e., SAW Chairman)
3 January 2010	CIE submits CIE independent peer review reports to the COTR
10 January 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

* The SARC Summary Report will not be submitted, reviewed, or approved by the CIE.

The SAW Chairman will assist the SARC chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the SAW Chairman will make the final SARC Summary Report available to the public. Staff and the SAW Chairman will also be responsible for production and publication of the collective Working Group papers, which will serve as a SAW Assessment Report.

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:

(1) each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each ToR as specified in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology, 1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc., 10600 SW 131st Court, Miami, FL 33186
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Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI), 22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel:

NMFS Project Contact:

Dr. James Weinberg
Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543
James.Weinberg@noaa.gov (Phone: 508-495-2352) (FAX: 508-495-2230)

Dr. Nancy Thompson, NEFSC Science Director
National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
nancy.thompson@noaa.gov Phone: 508-495-2233

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Findings of whether they accept or reject the work that they reviewed, and an explanation of their decisions (strengths, weaknesses of the analyses, etc.) for each ToR, and Conclusions and Recommendations in accordance with the ToRs. For each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the Independent Review Report should state why that Term of Reference was or was not completed successfully. To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the SARC Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not others read the SARC Summary Report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Assessment Terms of Reference for SAW/SARC51 (11/29 – 12/3, 2010)
(file vers.: 4/23/2010)

A. Silver hake (2 Stocks: Northern and Southern)

For each stock or combined,

1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.
2. Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty and any bias in these sources of data.
3. Evaluate the validity of the current stock definition, and determine whether it should be changed. Take into account what is known about migration among stock areas.
4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from Silver hake TOR-5), and estimate their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.
5. Evaluate the amount of silver hake consumed by other species as well as the amount due to cannibalism. Include estimates of uncertainty. Relate findings to the stock assessment model.
6. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.
7. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Silver hake TOR 6).
8. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
    c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.
9. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

B. Red hake (2 Stocks: Northern and Southern)

For each stock or combined,

1. Estimate catch from all sources including landings, discards, and effort. Characterize the uncertainty in these sources of data, and estimate LPUE. Analyze and correct for any species mis-identification in these data.

2. Present the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, etc.). Characterize the uncertainty in these sources of data.

3. Evaluate the validity of the current stock definition, and determine whether this should be changed. Take into account what is known about migration among stock areas.

4. Estimate measures of annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and characterize their uncertainty. Include a historical retrospective analysis to allow a comparison with previous assessment results.

5. State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

6. Evaluate stock status (overfished and overfishing) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Red hake TOR 5).

7. Develop and apply analytical approaches and data that can be used for conducting single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
    c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

C. Offshore hake

1. Use models to estimate the commercial catch. Describe the uncertainty in these sources of data.
2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.
3. Estimate measures of annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates.
4. State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.
5. Evaluate stock status (overfishing and overfished) with respect to the existing BRPs, as well as with respect to the "new" BRPs (from Offshore hake TOR 4).
6. If a model can be developed, conduct single and multi-year stock projections and for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs).
    a. Provide numerical short-term projections (3 years). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. In carrying out projections, consider a range of assumptions about the most important uncertainties in the assessment (e.g., terminal year abundance, variability in recruitment).
    b. Comment on which projections seem most realistic, taking into consideration uncertainties in the assessment.
    c. Describe this stock's vulnerability to becoming overfished, and how this could affect the choice of ABC.
7. Propose new research recommendations.

D. Longfin squid (*Loligo*)

1. Characterize the commercial catch including landings, effort, LPUE and discards. Describe the uncertainty in these sources of data.
2. Characterize the survey data that are being used in the assessment (e.g., regional indices of abundance, recruitment, age-length data, etc.). Describe the uncertainty in these sources of data.
3. Estimate annual fishing mortality, recruitment and stock biomass for the time series, and characterize the uncertainty of those estimates (consider *Loligo* TOR-4). Include a historical retrospective analysis to allow a comparison with previous assessment results.
4. Summarize what is known about consumptive removals of *Loligo* by predators and explore how this could influence estimates of natural mortality (M).
5. State the existing stock status definitions for the terms "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, and $F_{MSY;}$ and estimates of their uncertainty). Comment on the scientific adequacy of existing BRPs and for the "new" (i.e., updated, redefined, or alternative) BRPs.
6. Evaluate stock status with respect to the existing BRPs, as well as with respect to the "new" BRPs (from *Loligo* TOR 5).
7. Develop approaches for computing candidate ABCs (Acceptable Biological Catch; see Appendix to the TORs), and comment on the ability to perform projections for this stock.
8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in recent SARC reviewed assessments and review panel reports. Identify new research recommendations.

Appendix to the SAW TORs:

Clarification of Terms
used in the SAW/SARC Terms of Reference

(The text below is from DOC National Standard Guidelines, Federal Register, vol. 74, no. 11, January 16, 2009)

On "Acceptable Biological Catch":

Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of [overfishing limit] OFL and any other scientific uncertainty…" *(p. 3208)* *[In other words, OFL ≥ ABC.]*

ABC for overfished stocks. For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*

NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)

ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, [optimal yield] OY does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

On "Vulnerability":

"Vulnerability. A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Annex 3: Tentative Agenda

The project contact will provide the agenda at least two months before the review. As soon as the agenda is completed it will be sent to the NOAA COTR who will make it available to the CIE. Reviewers should plan to stay for the entire meeting.

SARC 51 – Fishery stock assessments of silver, red, and offshore hakes, and Loligo squid.

Woods Hole, Massachusetts during 29 November through December 3, 2010.

ANNEX 4: Contents of SARC Summary Report

1.

The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully.

To make this determination, the SARC chair and CIE reviewers should consider whether the work provides a scientifically credible basis for developing fishery management advice. Scientific criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. If the CIE reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

The report may include recommendations on how to improve future assessments.

2.

If any existing Biological Reference Point (BRP) proxies are considered inappropriate, include recommendations and justification for alternative proxies. If such alternatives cannot be identified, then indicate that the existing BRPs are the best available at this time.

3.

The report shall also include the bibliography of all materials provided during the SAW, and any papers cited in the SARC Summary Report, along with a copy of the CIE Statement of Work.

The report shall also include as a separate appendix the Terms of Reference used for the SAW, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

Cefas